

RAW MATERIALS: MAGNETIC CONTROL

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PARTICULARS OF MAGNETIC CONTROL OF IRON IMPURITIES IN FINE-GRAIN MEDIA — SECONDARY RAW MATERIALS (ASH WASTES)

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It is shown that the separation of iron impurities from ash wastes is best done by the method of wet magnetophoresis of iron impurities from an artificial suspension of the medium being analyzed and not by the method of magnetic control proved for free-flowing media on the basis of multioperational separation of iron impurities by dry magnetophoresis. Then the separated iron precipitates necessarily become magnetically enriched.

Key words: ash wastes, iron impurities, suspension, magnetic sectional separation, iron precipitate, magnetic enrichment.

Ash Wastes As a Free-Flowing Medium Uniquely Suited for the Control of Iron Impurities

Research on the possibility of using different technogenic wastes as alternative initial components in the production of materials and articles from glass and ceramic is becoming more and more topical. For example, aside from the preservation (or even improvement) of technical and technological production indices by means of resource conservation as well as the reduction and elimination of dumps of particular technogenic wastes, as noted in many works, the prospect of reducing the cost of production and the environmental burden at the same time is becoming realistic.

Of course, all this is also true for ash-slag wastes recommended for purposeful use, specifically, wastes comprised of fine ash particles [1, 2], whose already significant accumulations continue to increase as a result of the combustion of fuel in thermal power plants.

Research on the possibility and efficacy of using particular, potentially usable, technogenic wastes, including ash wastes, necessarily entails control of the content of impurities of different kinds, which almost always include iron impurities.

Such control is especially important in cases where limitations on the content of iron impurities are imposed on the initial material, for example, different natural raw materials: sand (GOST 22551), feldspar (GOST 15045), dolomite (GOST 23672), kaolin (GOST 21286) and other materials used in the glass, ceramic and other industries.

At the same time control of iron impurities is also important for rational discussions concerning the efficacy of using the attendant methods and equipment, for example, magnetic separators, to remove these impurities [3].

In the context of the possible use of magnetic separators, of the many methods for controlling iron impurities the methods of magnetic control, specifically, those recommended in GOST 25216, GOST 23789 and GOST 23672 for a number of natural raw materials, are preferable.

The main advantages of these methods (simplicity of implementation, designed specifically for determining the content of magnetically active iron impurities, i.e., those likely to be captured in a magnetic separator) as well as the drawbacks adversely affecting the accuracy of control are shown in [4 – 7]. These drawbacks have been eliminated in the method of operationally extrapolatable magnetic control, which has proven itself well [4 – 7].

The method based on the same well-known principle of multioperational magnetic separation of magnetic impurities, in contrast to the principle of accumulation of operational masses, which is used in the analog methods (see GOST 25216, GOST 23789 and GOST 23672), obliges the practi-

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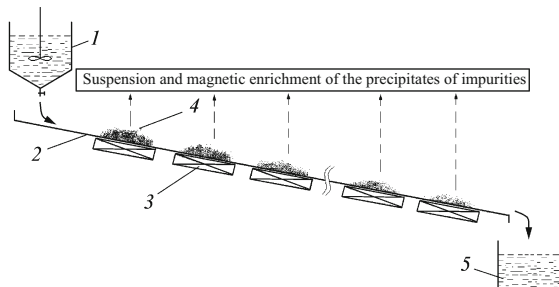


Fig. 1. Schematic diagram of iron-impurities analyzer: 1) tank with a suspension of particles of the medium being analyzed (ash wastes); 2) inclined chute; 3) sections of the magnetic system, creating local zones for capture and precipitation of iron suspensions; 4) iron precipitate, subjected to suspension and additional magnetic enrichment; 5) receiving tank for the analyzed medium, passed through the zone of magnetic precipitation of the iron impurities.

tioner to obtain an attendant function representing the variation (asymptotic reduction) of these masses. Even though it uses a limited number of operations (which is required to identify the function itself) this approach nonetheless makes it possible to calculate a key parameter — the total mass of the iron impurities present in the sample of the medium being analyzed [4–7] and hence the actual concentration (mass fraction) of the iron impurities.

Different variants of this method have been tested and are recommended for free-flowing and liquid media [4–8] on the basis of the principle of dry and wet magnetophoresis.

Tests have shown that the variants of the method of magnetic control adapted to free-flowing media cannot be implemented for ash wastes (properly prepared, a free-flowing medium consisting of fine particles). For example, because of their high dispersity the particles of such a medium (including particles of iron impurities) are prone to stick to one another, forming conglomerates and thereby impeding the method and therefore objective control.

On the Possibility of Controlling Iron Impurities in Ash Wastes by a ‘Nonspecific’ Variant of Wet Magnetophoresis: Filtration Entrainment Factor for Ash Particles

The above-noted difficulties in implementing operationally extrapolatable magnetic control of iron impurities in ash wastes (and other free-flowing media with very fine particles prone toward undesirable mutual conglomeration) are not fundamentally impossible to resolve.

To overcome these difficulties it is necessary to resort to a variant of wet magnetophoresis where the sample of ash wastes being analyzed is artificially put into the state of a suspension (water or other medium) in order to separate all particles (both ash and iron particles) and thereby eliminate the impediments to implementing magnetic control. In addition, because the presence of iron particles is comparatively

low it is precisely the ash particles that comprise the main disperse phase of this suspension.

Implementing the separation of iron particles by operation (section), for example, in a setup with an inclined chute (Fig. 1), and determining in so doing the mass m of the iron precipitate (dried), i.e., m_1, m_2, m_3, \dots and so on in each section, the dependence of m on the order number n of the operation-section is determined. Once the functional form of the dependence obtained is determined it can be objectively extrapolated beyond the limits of the actual experiment and the total mass of the iron impurities present in the sample can be determined (using the appropriate computational relations [4–9]).

At the same time it should be noted that a forced transition to the variant of wet magnetophoresis (see Fig. 1) raises an unfavorable factor adversely affecting the reliability of control of the iron impurities themselves. Thus, the iron precipitates continually formed (built up) in the sections comprise, essentially, filtering layers for the suspension (having a quite high concentration of ash particles) passing through them, so that these layers retain ash particles, i.e., the particles which are magnetically inactive. In consequence, in each of the masses formed during magnetic control a portion (measured subsequently in order to obtain the required characteristic) belongs to the retained ash particles.

To eliminate the ash particles entrained by the filtration effect each of the separate operational (sectional) masses of the iron precipitate must be suspended (see Fig. 1) and the comparatively small volumes of suspension obtained (in this case the suspension of already predominately iron particles with comparatively very small content of ash particles) must be subjected to additional magnetic treatment.

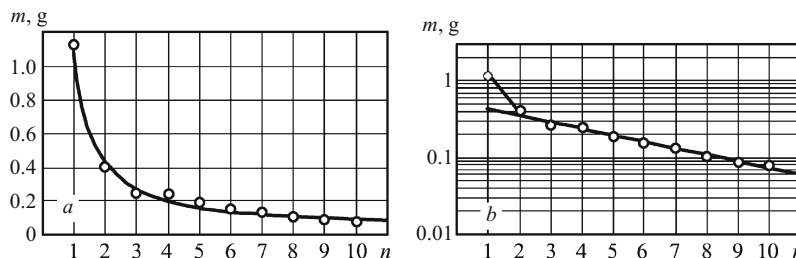
Such additional magnetic separation can be easily accomplished, for example, in a small container, with the magnet equipped with an easily removable shell (for subsequent detachment from the magnet and unimpeded removal of iron particles with it) executing circular motion covering the entire volume of the suspension. The technique can be used to extract virtually all of the iron particles from these operational (sectional) ‘repeated’ suspensions. The desired separation of the iron particles from the previously entrained (owing to the filtration factor) nonmagnetic ash particles is accomplished in the process.

This affords adequate magnetic enrichment by the iron particles of the separated operational masses of iron precipitates (in which, by the way, the ash particles are now ‘impurities’), i.e., concentrates of iron particles are obtained. It is these masses that are to be weighed (after drying) in order to obtain the requisite process mass characteristics for implementing magnetic control.

Operational Mass Characteristic for the Magnetic Control of Iron Impurities of Ash Wastes: Results of Control

The operational mass dependence (obtained by operational magnetic separation, shown in Fig. 1, of iron impuri-

Fig. 2. Operational (sectional) masses of iron precipitate after magnetic separation of the iron impurities from the general (primary) suspension of ash wastes followed by magnetic enrichment of operational (repeated) suspensions with iron particles in ordinary (*a*) and semi-logarithmic (*b*) coordinates: *n*) order number of operation.



ties followed by additional magnetic enrichment of the separated precipitates) of the magnetic control of iron impurities in ash wastes is shown in Fig. 2*a*. Evidently, aside from the first experimental point, all data are fitted quite well by a straight line in semilogarithmic coordinates (Fig. 2*b*).

The linear relation signifies that to within the empirical parameters *a* and *k* (easily determined from the experimental results) [4–8] these data are described by the discrete exponential relation

$$m = a \exp(-kn),$$

where $m = 0.52 \exp(-0.2n)$, decreasing asymptotically in a geometric progression with increasing number *n* of the magnetic-control operation (see Fig. 1). The total sum of the terms of this progression can be calculated.

Therefore, the total mass of the iron impurities contained in the experimental sample can be determined [4–8]. Of course, this pertains not only to the iron impurities actually separated (in this case first from the primary suspension and then from repeated suspensions) but also to the remaining iron impurities.

The case where a definite number *z* of the initial operational masses do not conform to the indicated exponential dependence (these masses seem to be magnified and, as can be seen in Fig. 2*b*, there is an initial steep section of the operational mass relation, which attests to the presence of a wide spectrum of sizes of iron-impurity particles containing comparatively large, easily precipitated particles [5, 7]). In this case the corresponding computational relation taking account of the simple summation of these masses, i.e., $m_1 + m_2 + \dots + m_z = m_{1...z}$, has the form [5, 7]

$$m_{1...z} = m_{1...z} + \frac{a}{e^{zk} (e^k - 1)}. \quad (1)$$

For the case considered here, where only the first operational mass of the precipitate is magnified (in Fig. 2*b* the value of *m* for *n* = 1), the computational relation (1) becomes

$$m_{1...z} = m_1 + \frac{a}{e^k (e^k - 1)}. \quad (2)$$

The calculations performed with the relation (2) for the parameters $a = 0.52$ g and $k = 0.2$ found above made it possible to establish the following. The total mass fraction *c* of

iron impurities in the present sample of ash wastes equals 13.3%:

$$c = (m_{1...z} / M) \times 100\% = 13.3\%,$$

where *M* is the initial mass of the ash-waste sample (before the primary suspension passed through the multisectional magnetic-separation system shown in Fig. 1 for separating iron impurities is prepared).

Similar calculations can be performed for other similar cases of magnetic control, including using the general relation (1), when a more extended initial steep section is observed in the operational mass characteristic obtained.

On the basis of the numerical value obtained for the required parameter, viz., the content of iron impurities in ash wastes (and other technogenic wastes) as well as technologically recommended addition to the raw mass of the product it is easy to determine the expected change in the content of iron containing impurities in this mass. However, by comparing the obtained data with the normalized (admissible) values it is possible to judge the expediency and potential efficacy of using, specifically, a magnetic separator to remove such impurities.

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